Name **Date**

HANDS-ON LAB

Applying a Constant Force

Try sliding a coin across a table with a constant force. You will find that it is not easy because the coin moves faster as you push. Gravity applies a constant force on objects. For that reason, using an object's weight as the applied force on a system is a straightforward way to apply a constant force. A descending mass will apply a constant force to an object attached to it via a string. This setup is sometimes called a modified Atwood machine.

RESEARCH QUESTION How does constant force affect an object’s motion?

MAKE A CLAIM

What will happen to the car's velocity when the weight is released?

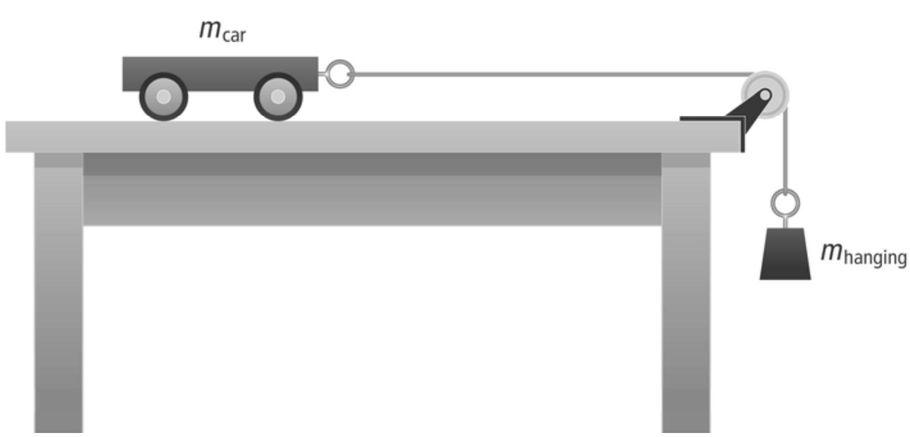
MATERIALS

- safety goggles
- box with foam pad to catch mass
- means of measuring mass, such as a force meter
- meterstick
- pulley attached to edge of table
- rolling car
- string, tied to the car
- timing device
- weight greater than car, tied to other end of string

SAFETY INFORMATION

- Wear safety goggles during the setup, hands-on, and takedown segments of the activity.
- Secure loose clothing, wear closed-toe shoes, and tie back long hair.
- Remember that falling masses can cause injury. Work with your teammates to operate the car-pulley system safely. One student should stop the car before it hits the pulley.
- Immediately pick up any items dropped on the floor so they do not become a slip/fall hazard.
- Wash your hands with soap and water immediately after completing this activity.

Figure 1: A string connects a car, which is free to roll, and a weight that is free to descend.



CARRY OUT THE INVESTIGATION

1. Measure the mass of the car and of the hanging mass.

mass of car (m_{car}) = ________ mass of hanging mass ($m_{hanging}$) = ________

2. Tie the car to the hanging mass, passing the string over a pulley as shown in **Figure 1**. Check that the hanging mass is adequately large to pull the car. If not, obtain a larger mass and measure the new mass.

3. Measure the distance between the bottom of the hanging mass and the ground (y_i). This is the distance that the hanging mass will travel. Make sure that the distance between the car and the pulley is greater than the distance between the hanging mass and the ground.

   Distance the hanging mass will travel $(y_\text{i}) =$ ______________________

4. Construct a data table that has columns for the trial number, time (t) in seconds, acceleration (**a**) in m/s^2, and observations. Use a spreadsheet to construct your table if one is available. See Step 6 for guidance about what formula you will use to calculate the acceleration of the system.

5. When your data table is ready, begin conducting trials of the investigation. Release the car and hanging mass, and time how long the hanging mass takes to reach the ground. Complete 10 trials, and calculate the average time.

6. Use the equation for acceleration, $y_\text{f} = y_\text{i} + \mathbf{v}_\text{i}t + \left(\frac{1}{2}\right)\mathbf{a}t^2$. Plug in y_i that you measured, $\mathbf{v}_\text{i} = 0$, and t that you measured. Solve for **a**. Record your calculated value in the data table.

ANALYZE

The net force on the car-string-hanging mass assemblage is equal to the weight of the hanging mass. Divide this force by the total mass, $m_\text{car} + m_\text{descending}$. Is your result similar to the value you measured for **a**? Is this what you expected? Explain your answer.

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CONSTRUCT AN EXPLANATION

1. **Construct Explanations** Using your observations of constant acceleration in this investigation, compare the motion of an object that has a constant acceleration to the motion of an object that has a changing acceleration.

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2. **Engage in Argument from Evidence** Perhaps you have been in a car when it travels over a bump. You may have felt your body lift from the seat for a moment, making you feel weightless. Astronauts also feel weightless as they orbit Earth in space. Are you or the astronaut actually weightless in these situations? Provide evidence and reasoning to support your claims.

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DRAW CONCLUSIONS

Write a conclusion that addresses each of the points below.

Claim What will happen to the car's velocity when the weight is released? Explain if your results confirm or refute your initial predictions.

Evidence What evidence from your investigation supports your claim?

Reasoning Explain how the evidence you gave supports your claim. Describe in detail the connections between the evidence you cited and the argument you are making.

EXTEND

1. Increase the mass of the car, and perform the same procedure. How does the greater mass affect the system's acceleration?
2. If the car was placed on a surface angled toward the pulley, would the acceleration increase or decrease? Explain your reasoning.
3. In future experimental designs, you might need a constant force. What details do you want to remember to optimize your future use of this technique?